Impact of biomass burning aerosols on clouds and cloud property retrievals

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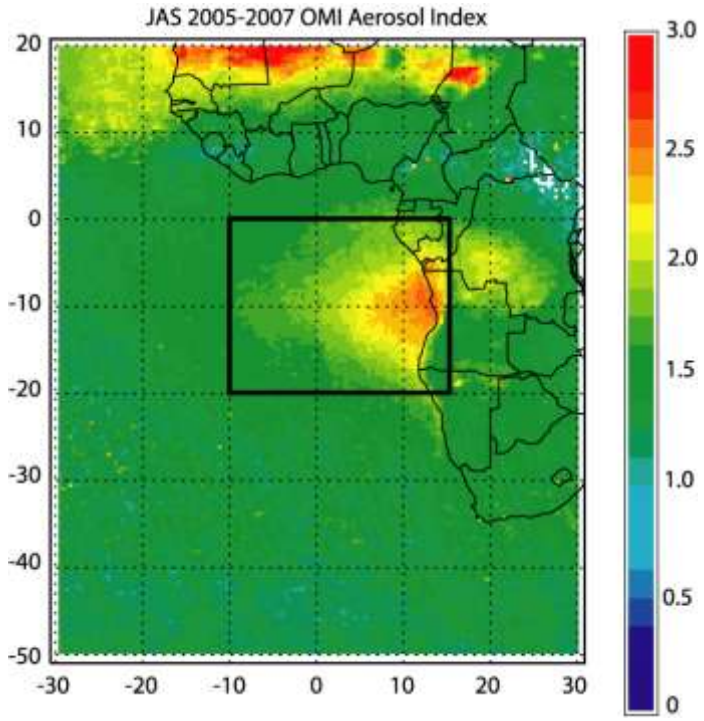
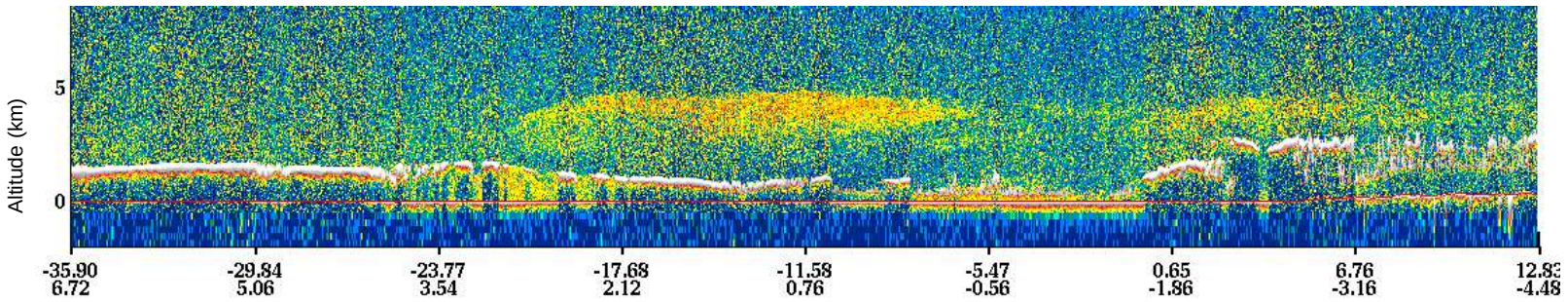
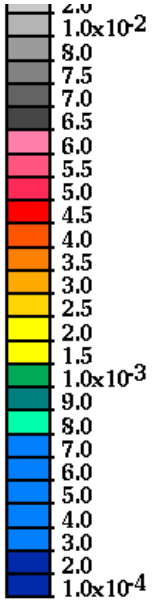
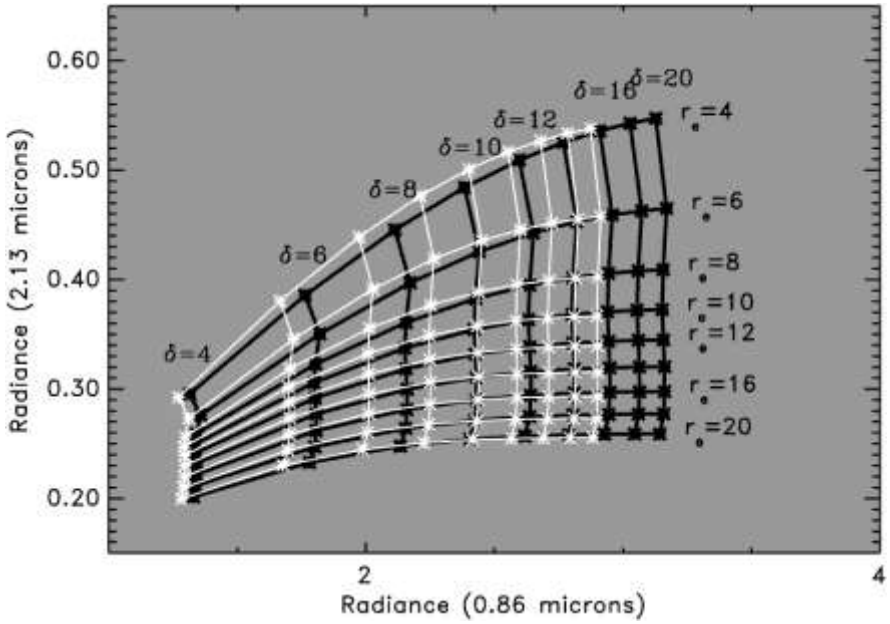


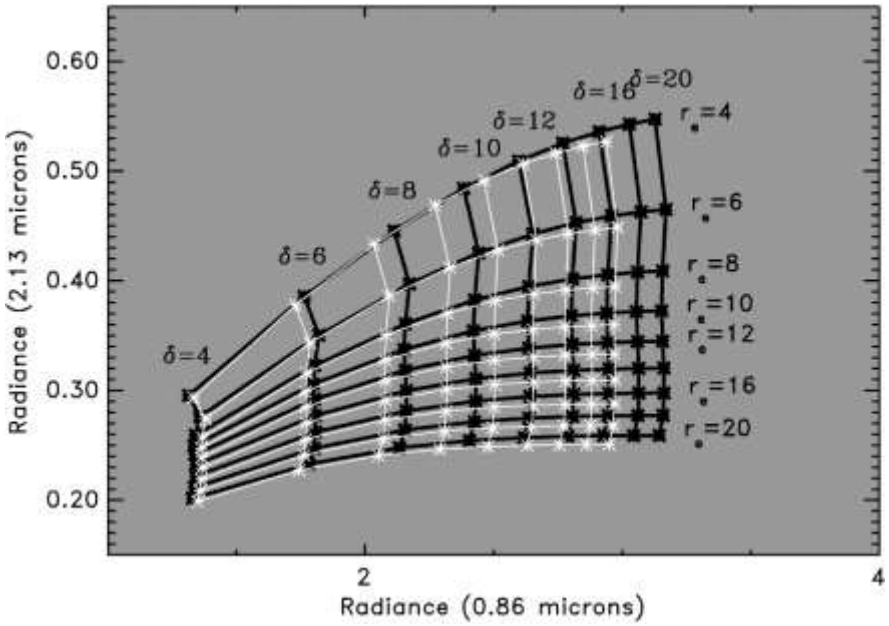
Calipso 532nm attenuated backscatter (km^{-1} sr^{-1})







Biomass burning aerosol over cloud
(mean aerosol $ssa_{0.87\mu m}$=0.86)

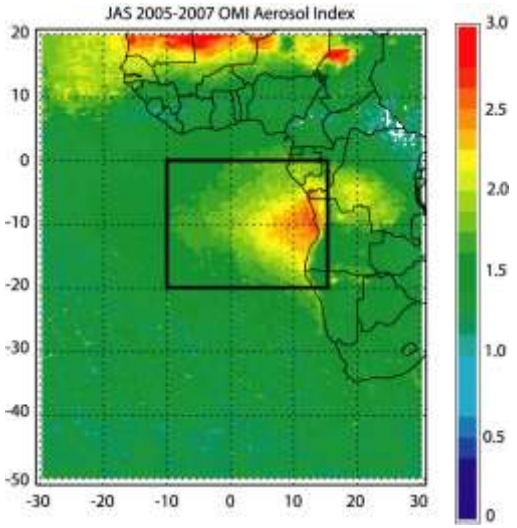


Dust aerosol over cloud
(mean aerosol $ssa_{0.87\mu m}$=0.96)

Haywood et al. (2004)

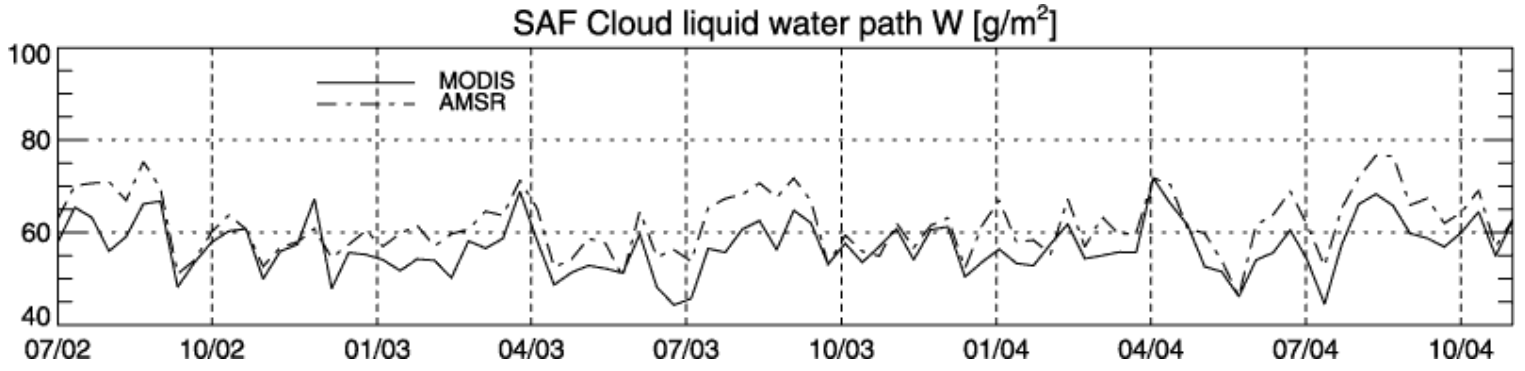
$$LWP_{MODIS} = 2/3\tau r_e$$

If MODIS τ or r_e reduced by absorbing aerosol layer, then there should be a corresponding bias in the LWP. Can use the independent AMSR-E LWP retrieval to diagnose.

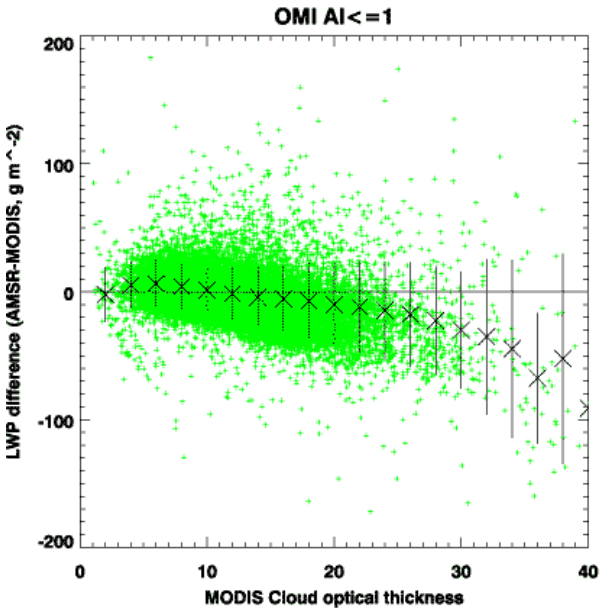


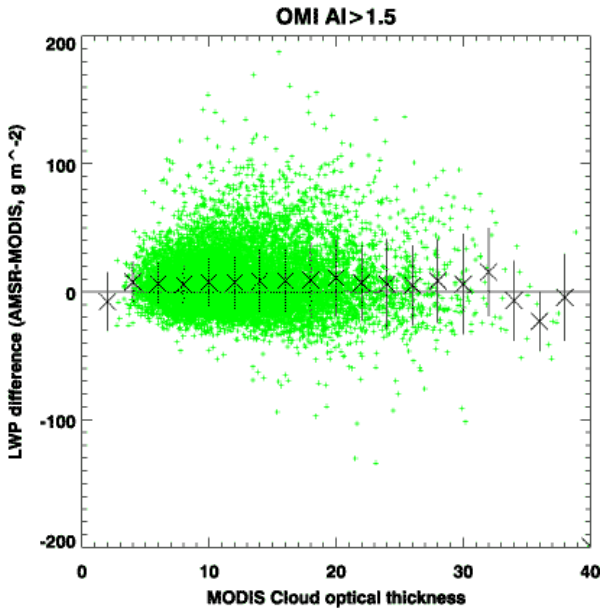
July, Aug. Sept. 2005 and 2006:

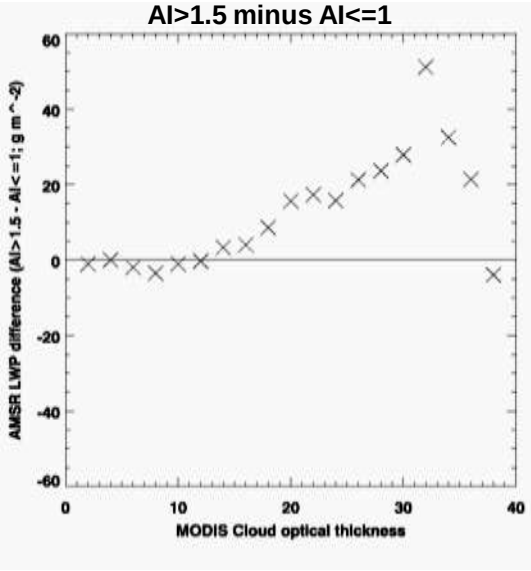
- MODIS LWP from level 2 1km pixels.
- AMSR-E LWP from Wentz et al. 0.25 deg. gridded.
- Grid cells are only used if all 1km MODIS pixels within the grid cell have a valid τ and r_e retrieval - confident overcast (~40% of cloud cover).
- OMI aerosol index is used to indicate presence of biomass burning aerosol.

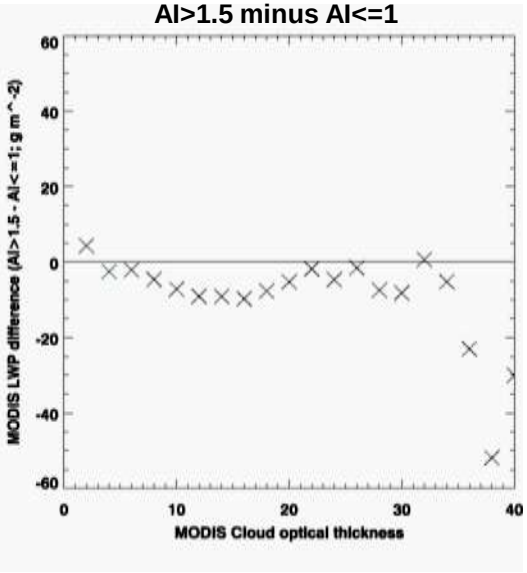


Bennartz (2007)

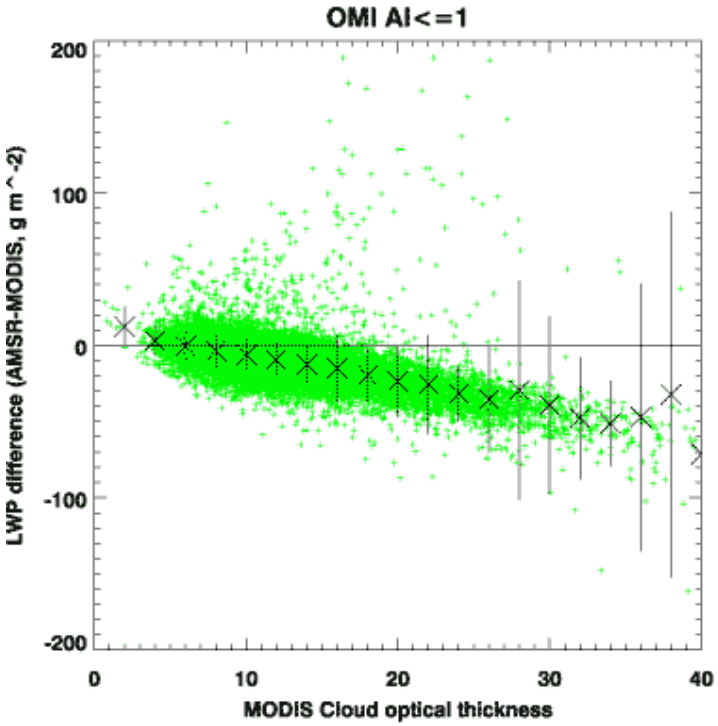

OMI AI<=1
LWP difference (AMSR-MODIS, g m^-2)
MODIS Cloud optical thickness


OMI AI>1.5
LWP difference (AMSR-MODIS, g m^-2)
MODIS Cloud optical thickness

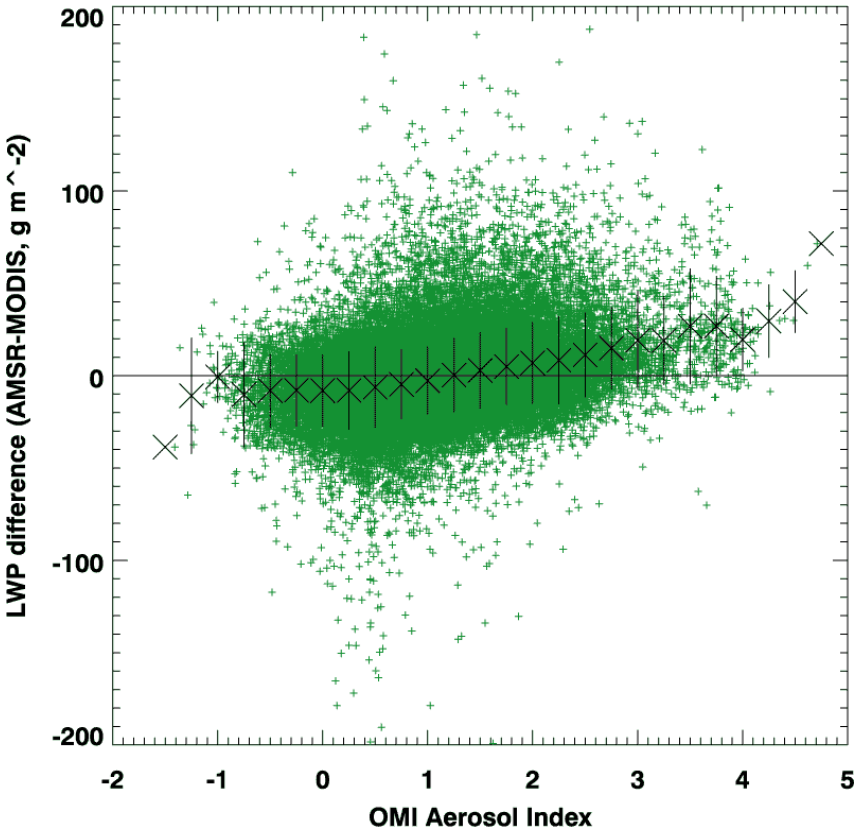

AI>1.5 minus AI<=1
AMSR LWP difference (AI>1.5 - AI<=1; g m^-2)
MODIS Cloud optical thickness


AI>1.5 minus AI<=1
MODIS LWP difference (AI>1.5 - AI<=1; g m^-2)
MODIS Cloud optical thickness

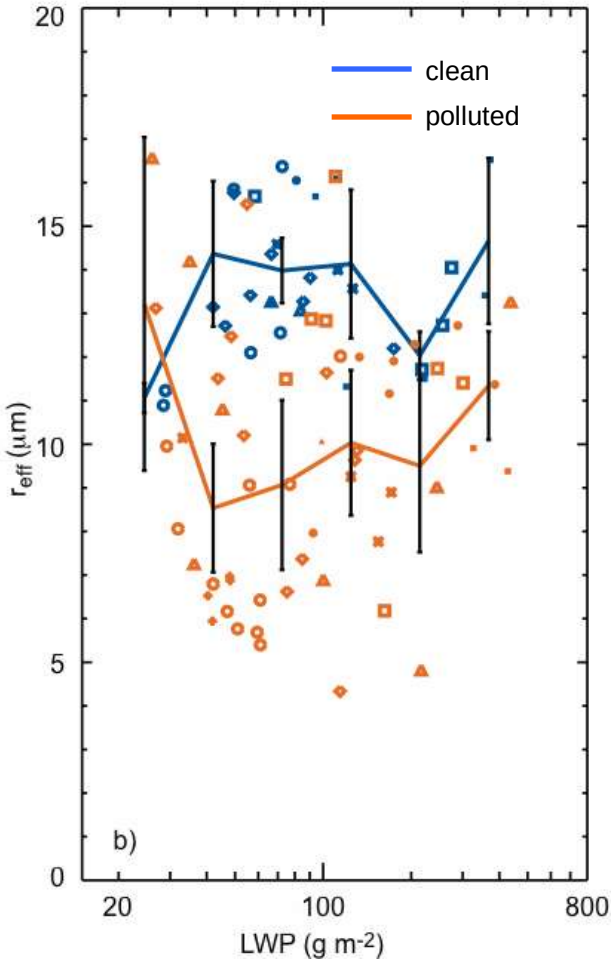
Southeast Pacific Ocean



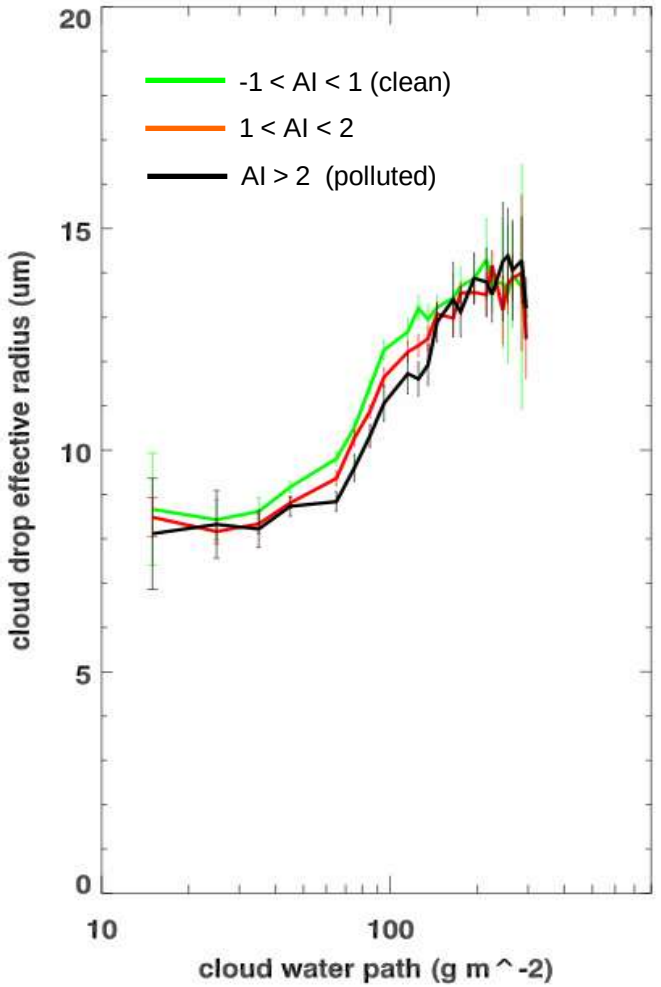
Note:virtually all data over S. Pac. are AI<=1


200
100
0
-100
-200
LWP difference (AMSR-MODIS, g m ^ -2)
-2
-1
0
1
2
3
4
5
OMI Aerosol Index

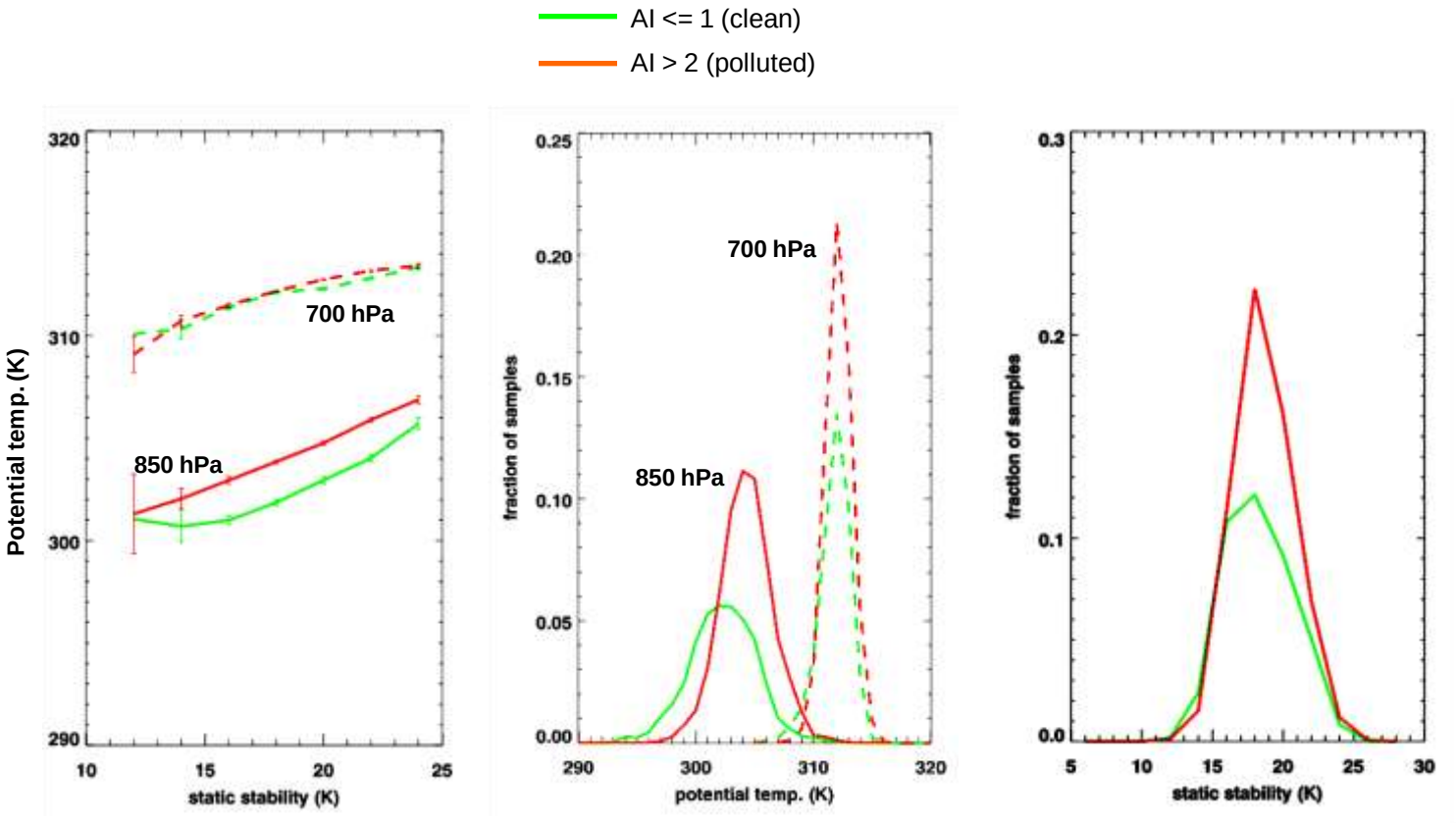
Overcast scenes from CIFEX
April 2004 N. Pacific Ocean



Overcast scenes over S. Atlantic
JAS 2005 - 2006



polluted is aerosol # conc. > 50 cm^{-3}
for particles 0.1 - 3.0 μm


AI <= 1 (clean)
AI > 2 (polluted)
Potential temp. (K)
320
310
300
290
700 hPa
850 hPa
10
15
20
25
static stability (K)
fraction of samples
0.25
0.20
0.15
0.10
0.05
0.00
700 hPa
850 hPa
290
300
310
320
potential temp. (K)
fraction of samples
0.3
0.2
0.1
0.0
5
10
15
20
25
30
static stability (K)

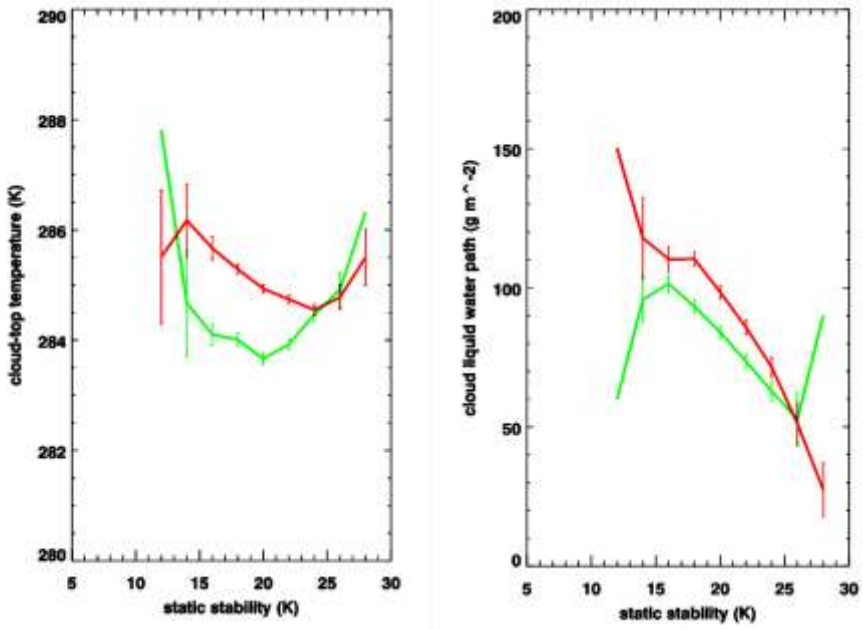
Hypothesis: Absorbing aerosols above the boundary layer strengthens the inversion and reduces cloud-top entrainment (Johnson et al. 2004).

This leads to:

- **greater LWP**
- **Lower cloud top**

AI <= 1 (clean)

AI > 2 (polluted)



Summary

- A low bias in the MODIS cloud optical thickness retrieval is expected for cases of biomass burning aerosol over low clouds (low bias up to 30%) which increases with cloud optical thickness.
- A comparison of MODIS and AMSR-E LWP retrievals indicates that there is a systematic bias for high aerosol cases that increases with cloud optical thickness.
- The bias only exceeds uncertainties in LWP retrievals for cases of OMI AI > 0.25 to 3.
- Little evidence is found of microphysical interaction of aerosols with cloud.
- For cases of similar lower-tropospheric stability, high OMI AI scenes have a higher 850 hPa temperature and higher LWP (by ~20 g m^{-2}). This supports the hypothesis that heating above the cloud by aerosol absorption can increase LWP through a reduction in cloud-top entrainment.